PTO 09-6715

CC = WO
19991125
A1
9960510

SYSTEM FOR ELECTRONICALLY IDENTIFYING A PLURALITY OF TRANSPONDERS

[Système d'identification electronique d'une pluralité de transpondeurs]

Thierry Roz

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. JULY 2009
TRANSLATED BY: MCELROY TRANSLATION COMPANY

PUBLICATION COUNTRY	(19):	WO
DOCUMENT NUMBER	(11):	9960510
DOCUMENT KIND	(12):	A1
PUBLICATION DATE	(43):	19991125
APPLICATION NUMBER	(21):	PCT/EP99/03347
APPLICATION DATE	(22):	19990514
INTERNATIONAL CLASSIFICATION[6]	(51):	G 06 K 7/00
PRIORITY COUNTRY	(30):	CH
PRIORITY NUMBER	(30):	1086/98
PRIORITY DATE	(30):	19980515
PRIORITY COUNTRY	(30):	EP
PRIORITY NUMBER	(30):	98110798.0
PRIORITY DATE	(30):	19980612
INVENTOR	(72),(75):	Thierry Roz
APPLICANT	(71):	EM MICROELECTRONIC-MARIN S.A.
DESIGNATED CONTRACTING STATES	(81):	JP, SG, US
TITLE	(54):	SYSTEM FOR ELECTRONICALLY IDENTIFYING A PLURALITY OF TRANSPONDERS
FOREIGN TITLE	[54A]:	Système d'identification electronique d'une pluralité de transpondeurs

FOR INFORMATION ONLY

Codes for the identification of PCT contract states on the cover sheets of the documents that publish the international applications in accordance with the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia-Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldavia
MG	Madagascar
MK	Macedonia (former Yugoslavian Republic of Macedonia)
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Vietnam
YU	Yugoslavia
ZW	Zimbabwe

The present invention relates to a system for a contactless electronic identification or RFID system. /1[*] These systems, which are used typically for identifying persons, animals or property (including: vehicles, articles requiring a labeling, subsets in a manufacturing chain, etc.), comprise primarily a querier/reader and one or several transponders each associated with an article to be identified.

In such a system, the querier/reader is typically arranged to transmit an interrogation signal in the form of electromagnetic radiation. The transponders that are subjected to this electromagnetic interrogation field respond by generating a reply signal consisting normally of a modulation of this field, and generally supplying a code/address identifying the transponder.

In any identification system comprising a plurality of transponders, there is potentially a risk of two or more queried transponders generating their signal response simultaneously, thus making their identification impossible. As a result, to identify each transponder individually and clearly, it is necessary to provide a communication protocol or "anti-collision protocol," allowing the effective management of this type of conflict. This problem has been addressed in various ways in the prior art.

Thus, the European Patent EP 0 494 114 describes such an identification system where each transponder is adapted to repeat the transmission of its reply signal for the purpose of increasing the probability of a successful reception of the latter by the questioner. The delays generated between each transmission of the reply signal are generally longer than the duration of the reply signal to allow the identification of a large number of transponders. A temporary inhibition signal is transmitted additionally to the correctly identified transponder in such a way as to remove it from the identification process and thus decrease interferences with the other transponders.

The solution described in this European Patent EP 0 494 114 turns out to be particularly adapted for the recognition of multiple transponders, although it is less effective in terms of transaction time for

[*] [Numbers in right margin indicate pagination of the original text.]

small quantities of transponders. The expression "transaction time" denotes the total time required /2 for the completion of the executed communication process, for example, the identification of each interrogated transponder. In addition, because the reply signals are transmitted at random time intervals, i.e., in a nonsynchronous way with respect to each other, it is necessary for the querier/reader to synchronize itself with each received reply signal.

Other identification methods are based on the development of a tree by systematically interrogating each transponder according to its unique identification code. In the US Patent 5,489,908, for example, it has thus been proposed to transmit an interrogation signal comprising a sequence of bits that is intended to be compared by each transponder with the less significant bits of the unique identification code stored in its memory. The transponders, whose identification codes do not include this sequence of bits thus suspend the transmission of their reply signal. The sequence of bits is then adapted until a unique transponder responds to the query.

The identification method is effective because it is systematic, but obviously it turns out to be a large consumer in terms of transaction time. It is also evident that two transponders possessing identical identification codes cannot be identified separately.

The US Patent 5,539,394 describes an identification system presenting an architecture of division and of temporal multiplexing. In this patent, the interrogation signal is thus used to generate the opening of a set of response windows with which the reader and the different interrogated transponders synchronize. A distribution algorithm is used by each transponder to determine the response window during which it will transmit its reply signal. For this purpose, the distribution algorithm is based on a distribution parameter (equivalent to the number of response windows) as well as to the data characteristic for each transponder, i.e., its unique identification code and/or any other data stored in its memory.

Upon the reception of a reply signal emanating from a unique transponder, the reader transmits in addition a temporary inhibition signal that removes the identified transponder from the continuation of the operation. A collision occurs, and several transponders transmit their reply signal during the same response window. As a result, the query cycle is reinitialized on the basis of a new distribution parameter, resulting in a different allocation of the response windows. This process is thus repeated /3
until each transponder is identified individually.

In an embodiment presented in this US Patent 5,539,394, the distribution algorithm consists in dividing the identification code of the transponder by a divisor (the distribution parameter) in such a way as to produce a remainder that corresponds to the response window in which the transponder will transmit its reply signal. The distribution parameter used as divisor is equivalent to the number of response windows used. It follows that it is thus not possible to identify individually transponders whose identification code is identical, because they will select invariably the same response window, regardless of the distribution parameter used.

In addition, in terms of transaction, only the response windows during which a unique reply signal is transmitted are optimally used. The windows during which no reply signal is transmitted, or during which a collision appears, generate waiting times that increase the total transaction time in substantial proportion. Indeed, it has been found that the total transaction time constitutes a critical element when one seeks to identify a set of transponders within as short a possible time limit.

The first purpose of the present invention is thus to propose an identification system allowing the generation of the problems connected with the identification of multiple transponders that potentially have identical identification codes.

A second purpose of the present invention is to propose an identification system whose transaction time required for the identification of the transponders is optimized as well as possible.

To achieve particularly the first above-mentioned purpose, the present invention relates to a first object, the method for the identification of a plurality of transponders located in a communication volume defined by an electrical field emanating from a reading unit, which method comprises the following steps:

a) transmission of said electromagnetic field allowing the activation of said transponders (TR_i) located in said communication volume;

b) transmission by said reading unit of an interrogation signal allowing the synchronization of said transponders and initializing the opening of a set of response windows intended for the reception of reply signals emanating from said transponders, where each one of said transponders comprises means for selecting a response window, from said set of response windows, during which this transponder then /4 transmits its reply signal;

c) sequential monitoring of the response windows to determine the receptions without collision of reply signals;

d) transmission of inhibition signals allowing the suspension, at least temporarily, of the activity of the transponders whose said respective reply signals are received without collision; and

e) repetition of the steps b) to d) until the reply signals of said plurality of transponders are detected without collision during the step c),

where this identification method is characterized in that said means to select a response window comprising random selection, at each new interrogation signal, determine randomly any response window from said set of response windows.

It results from these characteristics that the identification method allows a reduction of the collision rate between the different identification messages emanating from the interrogated transponders.

Indeed, the invention advantageously makes it possible for each transponder to select randomly a response window from an ordered set of response windows. The probability of collision is thus dependent on the number of allocated response windows and on the number of interrogated transponders, and no longer on the data contained in each transponder, as is the case in the document US 5,539,394 cited in the description of the prior art cited.

To achieve more precisely the second purpose of the invention, the present invention has as its second object a method for the identification of a plurality of transponders located in a communication volume defined by an electromagnetic field emanating from a reading unit, which method comprises the following steps:

a) transmission of said electromagnetic field allowing the activating of said transponders located in said communication volume;

b) transmission by said reading unit of an interrogation signal allowing the synchronization of said transponders and initializing the opening of a set of windows intended for the reception of reply signals emanating from said transponders, where each one of said transponders comprises means to select a /5
response window, from said set of response windows, during which this transponder then transmits its reply signal;

c) sequential monitoring of the response windows for the purpose of determining the states of occupation, namely nonuse, or receptions without collision of a reply signal;

d) transmission of an inhibition signal allowing the suspension, at least temporarily, of the activity of a transponder whose said reply signal is received without collision;

e) repetition of the steps b) to d) until the reply signals of said plurality of transponders are detected without collision during the step c),

where this identification method is characterized in that the total transaction time required for the identification of each one of said transponders is optimized by means for decreasing the duration of unused response windows.

It results from these characteristics that the identification method allows an optimization of the total transaction time required for the identification of the transponders.

Indeed, one advantage of the present invention is that it allows a reduction of the transaction time by decreasing the duration of an unused response window, allowing consequently a very substantial time savings.

According to a special embodiment, the method according to the invention is arranged in addition such that it decreases the duration of a response window during which a collision of several identification messages is detected.

Other characteristics and advantages of the invention will become apparent during the course of the following description, which is given only as an example and in reference to the drawings in the appendix in which:

- Figure 1 is a schematic representation of the principle of interrogating a plurality of transponders subjected to the interrogation electromagnetic field emanating from the reading unit;

- Figure 2 shows a simplified block diagram of a reading unit according to the invention;

- Figure 3a shows a simplified block diagram of a transponder according to the invention;

- Figure 3b presents a simplified block diagram of means allowing the random selection of a response /6
window according to the invention;

- Figure 4 illustrates the principle of allocation of the response windows according to the present invention;

- Figures 5 and 6 are flowcharts describing the course of the operations from the point of view of the reading unit and of the transponder, respectively, for a preferred embodiment of the invention;

- Figure 7a and 7b present a possible scenario illustrating the embodiment presented in Figures 5 and 6, where four transponders are interrogated by the reading unit.

Figure 1 is a schematic representation of the principle of interrogating several transponders TR_i subjected to an electromagnetic field 1 transmitted by a reading unit 20. The electromagnetic field 1 defines a communication volume 2 which encompasses the transponders TR_i. The communication volume 2 represents the area in which the transponders TR_i can capture a substantial part of the electromagnetic field allowing them to start functioning. The transponders TR_i are thus activated under the action of the electromagnetic field 1. The transponders TR_j, being located outside the communication volume 2, are not activated and consequently do not participate in the dialog with the reading unit 20.

In general, the reading unit 20 has the possibility of interrogating the transponders TR_i activated by transmitting an interrogation signal INT that consists typically of a modulation of the electromagnetic field 1. This interrogation signal INT indicates to the transponders TR_i that the reading unit 20 is ready to receive a reply signal REP_i comprising the required data, typically an identification code of the transponder.

According to the present invention, the interrogation signal INT comprises particularly a sequence allowing the synchronization of all the interrogated transponders TR_i. According to a special embodiment of the present invention, it is also proposed that the interrogation signal INT comprises a source code, i.e., a sequence that is common to a family of transponders, for example, a part of their identification codes, in such a way as to thus allow a preliminary screening of the activated transponders. This may turn out to be particularly useful for the purpose of restricting the

communication to a special family of transponders, for example, a family of keys allowing the opening of a vehicle, or a set of articles belonging to a defined class of products.

Figure 2 presents a simplified schematic of a reading unit 20 according to the present invention. It /7 comprises thus typically transmission means Tx and reception means Rx allowing the transmission of the interrogation signal INT and the reception of the reply signals REP_i emanating from the interrogated transponders TR_i, respectively. Modulation means 206 and demodulation means 208 allow the coding of the transmitted signals and the decoding of the received signals, respectively. The reading unit 20 comprises in addition processing means 202 that manage the course of the communication process, where these processing means 202 are coupled to storage means 204, typically a reprogrammable memory (for example, EEPROM), allowing the storage of the data received from the transponders TR_i or any other data required for the course of the communication process.

Figure 3a presents a simplified block diagram of a transponder TR_i according to the present invention. It comprises a resonating circuit 300 formed typically from an inductance and from a capacitance (both not shown in the figure) that are connected in parallel. A modulator 306 allows the encoding of the data to be transmitted, for example the identification code of the transponder, by load commutation of the resonating circuit 300. The modulator 306 is controlled by a control logics 302 coupled to memory 304. These memory means 304, typically EEPROM (or other types of reprogrammable memories) contain a code/address of the transponder and/or any other data recorded during the manufacture or later.

The transponder TR_i comprises in addition clock extraction means 312 supplying to control logics 302 a clock signal CLK derived from the frequency of the electromagnetic field 1 transmitted by reading unit 20. The encoding of the data is thus carried out in a synchronous way for each transponder.

The transponder TR_i in addition preferably comprises detection means 314, typically a monostable device, allowing the detection of brief interruptions of electromagnetic field 1. These detection means 314 allow particularly the detection of interruptions of electromagnetic field 1 that are generated by reading unit 20 and intended to transmit to the transponder TR_i a command notifying it to modify its state of communication, for example, by indicating to it to suspend its activity.

It is also preferred to use transponders of the passive type, i.e., transponders whose power supply is /8 extracted from the ambient electromagnetic field, in this case the electromagnetic field 1 transmitted by reading unit 20. For this purpose, the energy required for the functioning of the transponder TR_i is extracted from electromagnetic field 1 via resonating circuit 300 and then it is redressed by a rectifier 308. An initialization circuit 310 makes it possible to initialize control logics 302 when the power supply is sufficient to guarantee the proper operational functioning of the transponder. It should be noted that the use of transponders of the passive type is not essential for the present invention, and transponders of the active type can be used easily as substitutes for them.

In reference now to Figures 3b and 4, a description is provided below of the general principle of the functioning of the identification system according to the invention and more particularly the principle of random selection of a response window. Thus, according to the schematic representation of Figure 4, after the transmission of the interrogation signal INT by reading unit 20, a set of n windows $SLOT_k$ ($k = 1$ to n), is generated. Each transponder TR_i comprises means for selecting, according to a random process, a special response window from the set of n response windows $SLOT_k$ that are available, during which it will transmit its reply signal REP_i.

The process of random selection of a response window is described in greater detail below in reference to Figure 3b. This figure presents a simplified block diagram of an example of means allowing the random selection of a response window. Each transponder TR_i thus comprises preferably an

oscillator RC 402 delivering a clock signal RND CLK to a counter 404. This arrangement comprises in addition a loading logics 400 allowing the loading of the instantaneous value of the counter 404 in a register 406, where the value so loaded in register 406 is representative of the number of the response window in which the transponder will emit its reply signal, as explained below.

The oscillator RC 402 comprises elements of low tolerance and of high sensitivity to the temperature and the operating conditions. These characteristics thus lead to large disparities between oscillators RC 402 of each transponder TR_i. These divergences are reflected in addition in a greater diversity of the /9 values delivered at the output of counter 404 for each transponder.

It should be noted that it is also preferred to choose oscillators RC 402 that deliver a clock signal RND CLK whose frequency is substantially higher than the frequency of the clock signal CLK extracted from electromagnetic field 1, this in such a way as to accentuate the divergences between the values that are representative of the number of the response window, and generated by counter 405 of each transponder TR_i.

As soon as the transponder has been activated, the oscillator RC 402 thus delivers the clock signal RND CLK, incrementing the counter 404. Upon reception of interrogation signal INT, loading logics 400 then proceed to the loading of the instantaneous value of the counter in the register 406. It should be noted that counter 404 continually generates values as long as the transponder is awake, and regardless of what operations are in the process of being executed. The loading command transmitted by the loading logics 404 thus allows fixing in register 406 of the instantaneous value of counter 404.

It should be noted that the process of random selection of a response window does not overcome the collision problem totally. It will therefore be necessary to re-execute a new interrogation cycle if a dispute appears between several reply signals REP_i. Consequently, the total transaction time required for

the identification of all the interrogated transponders TR_i will depend on the total number of interrogation cycles carried out.

According to a second appearance of the invention, the identification method is preferably arranged to allow the optimization of the total transaction time required for the identification of each one of the transponders by managing the occupation of the response window $SLOT_k$ ($k = 1$ to n). Three cases can indeed present themselves during a response window. The first case is characterized by a transmission without collision of a reply signal REP during the response window. In this case, the transponder issuing the reply signal can thus be identified individually. This transponder is then inhibited typically in such a way as to remove it from a subsequent interrogation cycle. According to an embodiment of the present invention, the reading unit 20 thus transmits an inhibition signal MUTE that allows the suspension of the activity of the transponders whose respective reply signals are received without collision.

The second case is characterized by the absence of the transmission of a reply signal REP during the response window. An important saving in terms of transaction time can thus be achieved by decreasing the duration of the unused response windows. Indeed, it is possible to determine, already after a certain period of the response window, whether it is used or not. According to an embodiment of the invention, the total transaction time required for the identification of each one of the transponders is thus optimized by means for decreasing the duration of the unused response windows.

The third case that can present itself is characterized by a simultaneous transmission of two or several reply signals during the response window. In this case, it is also possible to determine, already after a certain period of the response window, whether a collision appears, because the data that is being received by the reading unit is altered by the superposition of several reply signals. According to an embodiment of the present invention, the transaction time required for the identification of each one of

the transponders is also optimized by means for decreasing the duration of the response windows during which a collision is detected.

An example of an embodiment of means for decreasing the duration of the response windows for the cases presented above will be described in greater detail in the continuation of the description in reference to Figures 5-7. It is moreover important to note that the optimization of the transaction time as presented in the present description is applicable regardless of what principle (random or deterministic) is adopted for selecting the response windows.

Figure 5 presents a flowchart describing the course of the operations carried out by reading unit 20 for a preferred embodiment. The communication protocol will thus start by the transmission of electromagnetic field 1, represented by block 500. The interrogation cycle is initialized in block 502 by the transmission of the interrogation signal INT. This signal allows the synchronization of the interrogated responders with reading unit 20 and launches the process of random selection of a response window.

As represented schematically in block 504, a verification is carried out first to determine whether the /11
interrogation cycle has reached its end. In the affirmative case, reading unit 20 proceeds to decision block 518, a point to which we will return below. In the negative case, reading unit 20 then examines the current response window SLOT to verify its state of occupation. During this operation, represented in block 506, reading unit 20 tests whether a reply signal REP has been received after a certain period of the current response window. If such is the case, i.e., if a positive response is supplied to the output of decision block 508, the process continues its course. Otherwise, reading unit 20 generates a window shift signal SHIFT, this window shift signal SHIFT indicating to all the transponders that are active the advance to the next response window SLOT. The same operation, represented in block 512, is carried out if a collision is detected, which is reflected in a positive response at the output of decision block 510

indicating collisions. In this case, an indicator specifying that a collision has appeared during the interrogation cycle is activated at block 511 before the transmission of the window shift signal SHIFT. In the case where no collision is detected at block 510, the process continues its course as indicated.

Upon reception without collision of a reply signal, the data transmitted by the interrogated transponder, typically its identification code, is stored at block 514 in the memory of reading unit 20. The data that has thus been stored will allow reading unit 20 to address subsequently the transponder concerned. At block 516, reading unit 20 generates, as a complement, an inhibition signal MUTE indicating to the transponder concerned that it has been identified and that it can suspend its activity, at least temporarily. Following the transmission of the inhibition signal MUTE, a window shift signal SHIFT is also transmitted to indicate the advance to the next response window SLOT.

Each response window is thus examined according to the course presented above, until decision block 504 indicates that the interrogation cycle is completed. If a collision has been detected during one of the response windows, in other words, if the collision indicator has been activated at block 511, it will be necessary to undertake a new interrogation cycle. The interrogation cycle is thus repeated until the time when decision block 518 no longer indicates any collision.

At the end of the communication protocol, at block 520, it is then possible to address each /12
identified transponder individually on the basis of the data stored in memory at block 514.

In reference to Figure 6, a description is now provided of the course of the operations from the point of view of a transponder TR for the preferred embodiment described above in reference to Figure 5. The responder is awakened, at block 600, under the action of electromagnetic field 1 transmitted by reading unit 20. The transmission of the interrogation signal INT is then captured by the transponder at block 602. This interrogation signal INT defines a temporal reference with respect to which the transponder is synchronized.

The random process of selection of the response window SLOT is represented in the following block 604. As described above, this selection consists in determining a SLOT response window number during which the transponder will transmit its reply signal REP.

Subsequently, as indicated at block 606, the transponder TR waits for the appearance of the selected response window SLOT. For this purpose, the transponder TR counts the window shift signals SHIFT transmitted by reading unit 20 during this period until the appearance of the selected response window SLOT. These operations are represented at blocks 607 and 608, respectively.

During the selected response window SLOT, at block 609, the transponder thus proceeds to the transmission of the reply signal REP. If, in parallel with this transmission, the transponder describes a window shift signal SHIFT indicating to it that its reply signal has entered into a collision, it suspends its transmission, according to what is indicated by blocks 610 and 611, and it waits for the re-execution of a new interrogation signal at block 602.

In the case where the reply signal was transmitted without impediment, the transponder waits, at block 612, for the reception of an inhibition signal MUTE indicating to it that it has been identified correctly. If this signal is received, the transponder is inhibited temporarily, as indicated at block 614, to remove it from the population of interrogated transponders. Otherwise the transponder waits for the re-execution of a new interrogation cycle at block 602.

Figures 7a and 7b represent a possible scenario illustrating the embodiment presented in Figures 5 and 6, where four transponders TR_1 to TR_4 are awakened under the action of electromagnetic field 1 /13
transmitted by reading unit 20. Following the generation of the interrogation signal INT, reading unit 20 opens a set of n temporal response window $SLOT_k$; in the present case 8 response windows referenced $SLOT_1$ to $SLOT_8$ have been represented as an example. Each transponder TR_i (i = 1, 2, 3, 4) chooses randomly a response window during which it transmits its reply signal REP_i (i = 1, 2, 3, 4). In the

example presented in Figures 7a and 7b, the situation has thus been illustrated where transponders TR_1, TR_2, TR_3 and TR_4 have chosen response windows $SLOT_4$, $SLOT_7$, $SLOT_2$ and $SLOT_4$, respectively. One thus notes that reply signals REP_1 and REP_4 of the transponders TR_1 and TR_4 enter into collision during the response window $SLOT_4$.

Since the response windows $SLOT_1$, $SLOT_3$, $SLOT_5$, $SLOT_6$ and $SLOT_8$ are not used by each one of the transponders TR_i ($i = 1, 2, 3, 4$), a window shift signal SHIFT is thus generated after a certain period of the response window. A window shift signal SHIFT is also generated during the response window $SLOT_4$ following the collision between reply signals REP_1 and REP_4 of transponders TR_1 and TR_4, respectively, where this window shift signal SHIFT is interpreted by the transponders TR_1 and TR_4 in such a way that they suspend the transmission of the reply signals REP_1 and REP_4.

An inhibition signal MUTE is transmitted to transponders TR_2 and TR_3 for which the reception took place without collisions. The transponders TR_2 and TR_3 are thus removed temporarily from the population of the interrogated transponders. This inhibition signal MUTE is followed by a window shift signal SHIFT to indicate the advance to the next response window.

A second interrogation cycle (not shown) must be re-executed in a way allowing the identification of the remaining two transponders TR_1 and TR_4. Thus, one can understand the low probability of a collision occurring again during the following interrogation cycle.

Figure 7b illustrates the above-described scenario in the form of temporal diagrams where the reply signals REP_i emanating from each transponder TR_i ($i = 1, 2, 3, 4$), as well as the signals MUTE and SHIFT transmitted by reading unit 20, are schematically represented, respectively. This figure allows in addition the observation that the duration of the response windows during which no reply signal is transmitted, or during which a collision is detected, is reduced by the transmission of the window shift signals SHIFT, this thus allowing a substantial decrease of the duration of the interrogation cycle. /14

The window shift signals SHIFT and temporary inhibition signals MUTE are formed preferably from one or several momentary interruptions of electromagnetic field 1 transmitted by reading unit 20. For this purpose, detection means 314 associated with control logics 302 (Figure 3a) of each transponder is used to monitor whether such interruptions which are characteristic of a shift signal SHIFT or an inhibition signal MUTE are generated by reading unit 20.

It should be noted that in the above-described embodiment in reference to Figures 5-7, a window shift signal SHIFT is transmitted in such a way as to indicate the advance to the next response window. Each transponder counts the window shift signals SHIFT transmitted by the reading unit until the appearance of the selected response window. Thus, it is possible to prolong if necessary the duration of a response window, for example, in such a way as to address a transponder as soon as it has been identified.

Alternatively, it is also proposed to fix a predetermined duration for each response window, where this duration has to be sufficient to allow the transmission of reply signals. In that case, a window shift signal is then required only in case the response window is not used or if a collision is detected. In addition, the window shift signal SHIFT can thus be interpreted by the transponders that are active in such a way that they advance the transmission of their reply signal by a duration corresponding to the remaining duration of the response window.

Finally, it should be noted that some applications do not necessarily require the identification of the totality of the interrogated transponders. Thus, for example, a remote opening system for a vehicle which is associated with a set of transponders (or "keys") requires only the identification of the first transponder transmitting its reply signal without collision, and this after as short as possible a delay. In the illustration of Figure 7a, this would thus be reflected in the end of the interrogation cycle upon reception of the reply signal REP_3 emanating from the transponder TR_3.

Claims /15

1. Method for the identification of a plurality of transponders (TR_i) located in a communication volume (2) defined by an electromagnetic field (1) emanating from a reading unit (20), which method comprises the following steps:

a) transmission of said electromagnetic field (1) allowing the activation of said transponders (TR_i) located in said communication volume (2);

b) transmission by said reading unit (20) of an interrogation signal (INT) allowing the synchronization of said transponders (TR_i) and initializing the opening of a set of response windows ($SLOT_k$, k = 1 to n) intended for the reception of reply signals (REP_i) emanating from said transponders (TR_i), where each one of said transponders (TR_i) comprises means for selecting a response window, from said set of response windows ($SLOT_k$, k = 1 to n), during which this transponder then transmits its reply signal;

c) sequential monitoring of the response windows ($SLOT_k$, k = 1 to n) to determine the receptions without collision of reply signals (REP_i);

d) transmission of inhibition signals (MUTE) allowing the suspension, at least temporarily, of the activity of the transponders whose said respective reply signals (REP_i) are received without collision; and

e) repetition of the steps b) to d) until the reply signals of said plurality of transponders are detected without collision during the step c),

where this identification method is characterized in that said means to select a response window comprising random selection, at each new interrogation signal (INT), determine randomly any response window from said set of response windows ($SLOT_k$, k = 1 to n).

2. Identification method according to Claim 1, characterized in that the total transaction time required for the identification of each one of the transponders (TR_i) is optimized by means for decreasing the duration of the unused response windows.

3. Identification method according to Claim 1 or 2 in which said sequential monitoring of the response window slot ($SLOT_k$, k = 1 to n) is provided to detect also a collision between several reply signals within any response window, characterized in that the total transaction time required for the /16
identification of each one of said responders (TR_i) is optimized by means for decreasing the duration of windows within which a collision between several reply signals (REP_i) is detected.

4. Identification method according to Claim 1, 2 or 3, characterized in that said random selection means comprise means (402) that allow the generation of a random clock signal (RND CLK) for the duration of the activation of the transponder, means (404) allowing a cyclic incrementation, on the basis of which the random clock signal (RND CLK), by a value that is representative of a response window, means (400, 406) allowing the loading of this value that is representative of the response window selected during the transmission of said interrogation signal (INT).

5. Identification method according to Claim 4, characterized in that the frequency of said random clock signal (RND CLK) is substantially higher than the frequency of a clock signal used for the internal functioning of said transponders (TR_i).

6. Method for the identification of a plurality of transponders (TR_i) located in a communication volume (2) defined by an electromagnetic field (1) emanating from a reading unit (20), which method comprises the following steps:

a) transmission of said electromagnetic field (1) allowing the awakening of said transponders (TR_i) located in said communication volume (2);

b) transmission by said reading unit (20) of an interrogation signal (INT) allowing the synchronization of said transponders (TR_i) and initializing the opening of a set of response windows ($SLOT_k$, k = 1 to n) intended for the reception of reply signals (REP_i) emanating from said transponders (TR_i), where each one of said transponders (TR_i) comprises means to select a response window, from said set of response windows ($SLOT_k$, k = 1 to n), during which this transponder then transmits its reply signal;

c) sequential monitoring of the response windows ($SLOT_k$, k = 1 to n) for the purpose of determining the states of occupation, namely nonuse, or a reception without collision of a reply signal (REP_i);

d) transmission of an inhibition signal (MUTE) allowing the suspension, at least temporarily, of the activity of a transponder whose said reply signal (REP_i) is received without collision; /17

e) repetition of the steps b) to d) until the reply signals of said plurality of transponders are detected without collision during the step c),

where this identification method is characterized in that the total transaction time required for the identification of each one of said transponders (TR_i) is optimized by means for decreasing the duration of unused response windows.

7. Identification method according to Claim 6 in which said sequential monitoring of the response windows ($SLOT_k$, k = 1 to n) is also provided to detect a collision between several reply signals within any response window, characterized in that the total transaction time required for the identification of each one of said transponders (TR_i) is in addition optimized by means for decreasing the duration of windows within which a collision between several reply signals (REP_i) is detected.

8. Identification method according to any one of Claims 1-7, characterized in that said inhibition signal (MUTE) consists of one or several momentary interruptions of said electromagnetic field (1).

9. Identification method according to any one of Claims 1-8, characterized in that said interrogation signal (INT) comprises in addition a source code that is representative of a predetermined family of transponders, said source code allowing a preliminary screening out of all the transponders that do not belong to said family of transponders.

10. Reading unit (20) allowing the identification of a plurality of transponders (TR_i) located in a communication volume (2) defined by an electromagnetic field (1) emanating from said reading unit (20), where said reading unit (20) comprises transmission means (Tx) that are connected to modulation means (206), reception means (Tx) that are connected to demodulation means (208), processing and control means (202) and memory means (204), where this reading unit (20) is arranged so as to

a) activate said transponders (TR_i) by the transmission of said electric magnetic field (1);

b) transmit an interrogation signal (INT) allowing the synchronization of said transponders (TR_i), /18
and initializing the opening of a set of response windows ($SLOT_k$, k = 1 to n) which are intended for the reception of reply signals (REP_i) emanating from said transponders (TR_i),

c) examine sequentially each one of the response windows ($SLOT_k$, k = 1 to n) for the purpose of determining among them the states of occupation, notably nonuse, or a reception without collision of a reply signal (REP_i);

d) transmit an inhibition signal (MUTE) allowing the suspension, at least temporarily, of the activity of a transponder whose said reply signal (REP_i) is received without collision; and

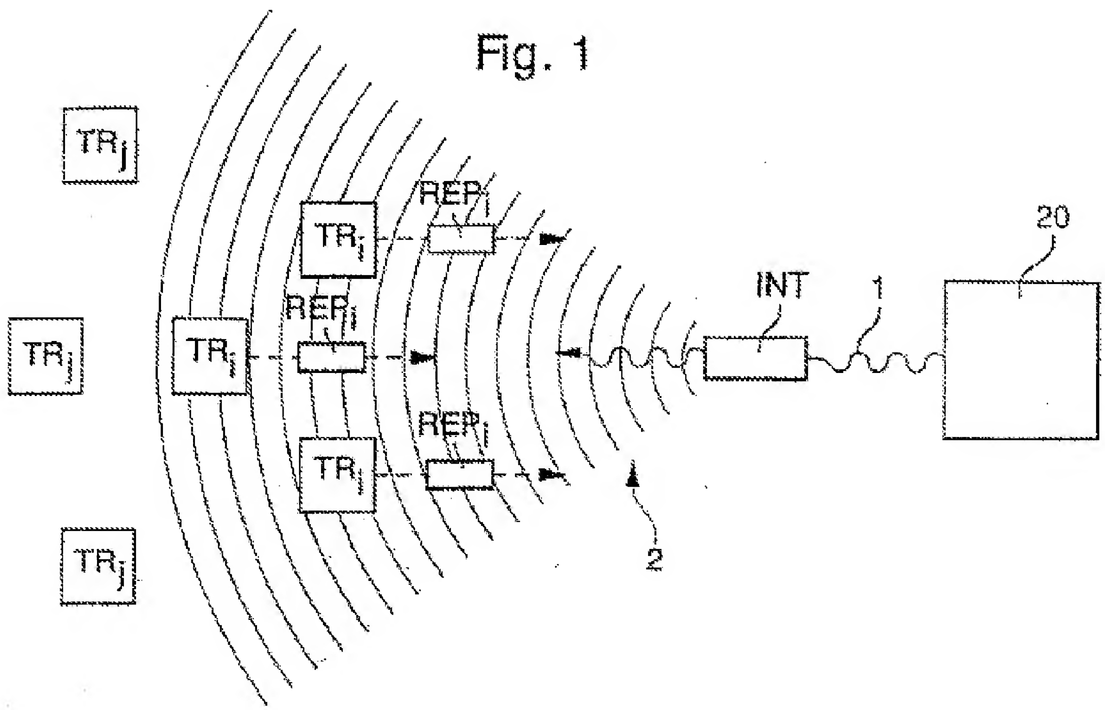
e) repeat the steps b) to d) until the reply signals of said plurality of transponders are detected without collision during,

where this reading unit (20) is characterized in that it is arranged such that it transmits a signal which allows decreasing the duration of any response window when no reply signal (REP_i) is received in this response window.

11. Reading unit (20) according to Claim 10, characterized in that it is arranged in addition so as to transmit a signal of decrease of the duration of a reply signal when a collision between several reply signals (REP_i) is detected in this response window.

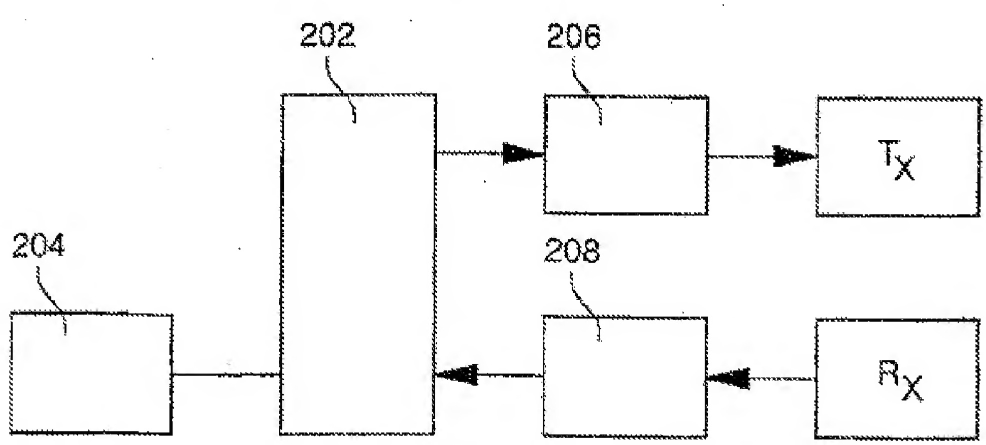
12. Transponder (TR) comprising communication means (300, 306), processing and control means (302), memory means (304), and means responding to the reception of an interrogation signal (INT) emanating from a reading unit (20) and allowing the selection of one response window, from a set of response windows ($SLOT_k$, k = 1 to n), during which this transponder transmits a reply signal (REP), where this transponder is arranged so as to suspend its activity, at least temporarily, upon the reception of an inhibition signal (MUTE), where this transponder is characterized in that said means for selecting a response window comprise random selection means which, at each new interrogation signal (INT), determine in a random way any response window from said set of response windows ($SLOT_k$, k = 1 to n).

Fig. 1



TR$_j$
TR$_j$
TR$_j$
TR$_i$
TR$_i$
TR$_i$
REP$_i$
REP$_i$
REP$_i$
INT
1
20
2

Fig. 2



202
206
204
208
T$_X$
R$_X$

1 / 6

Fig. 3a

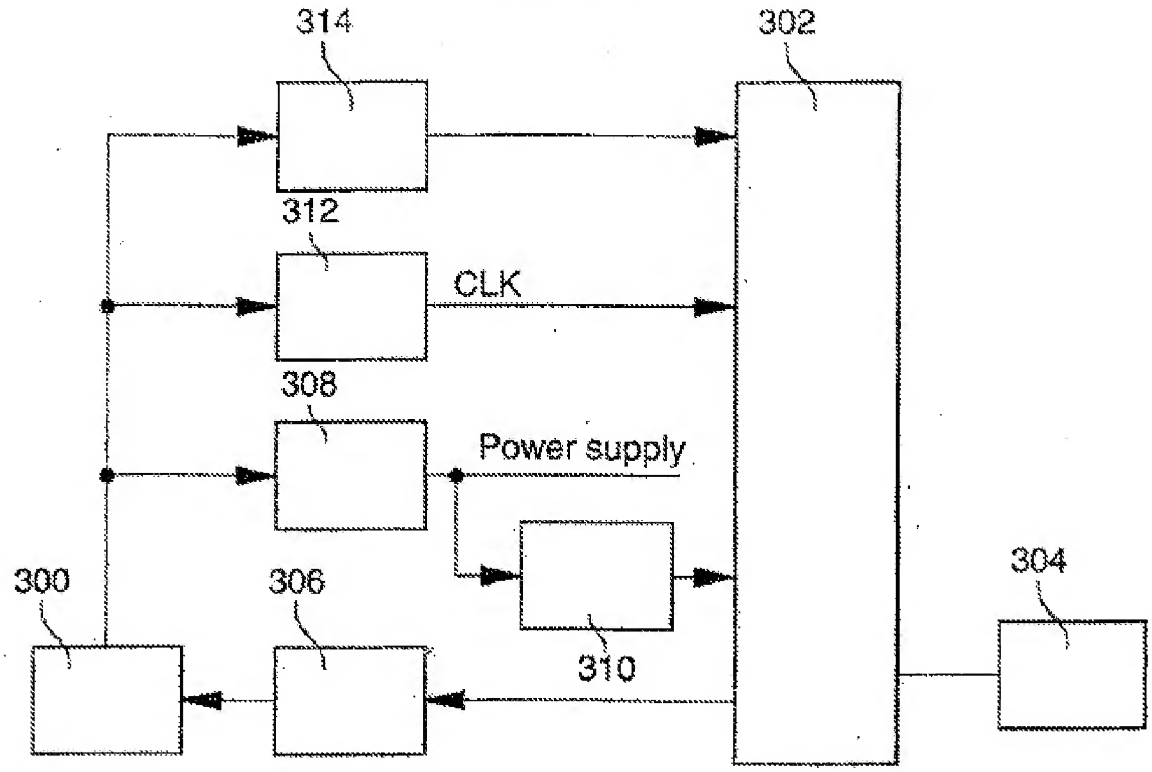
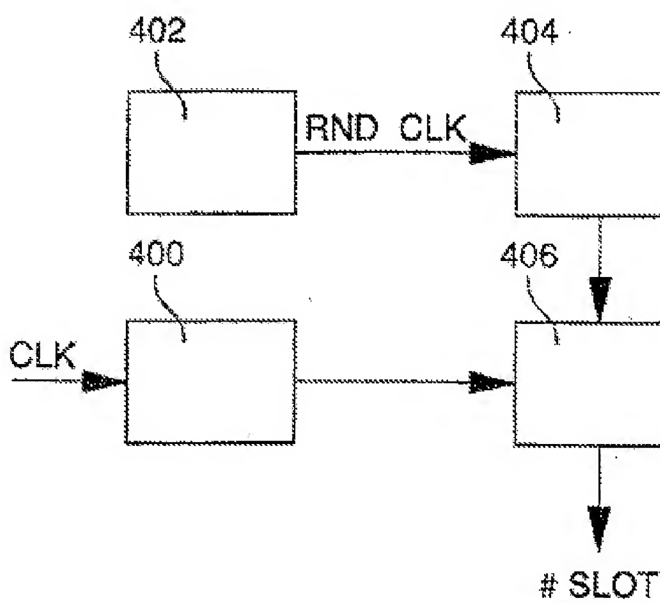
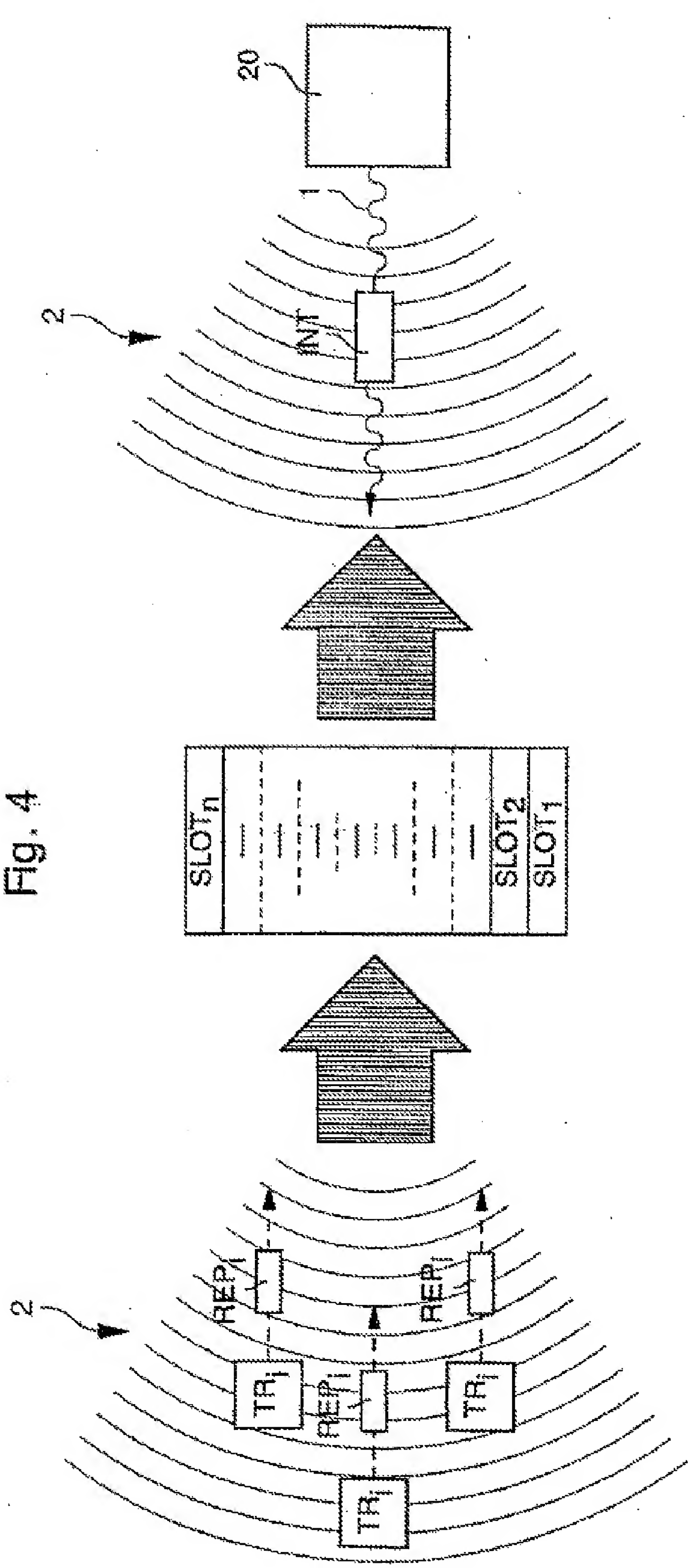


Fig. 3b

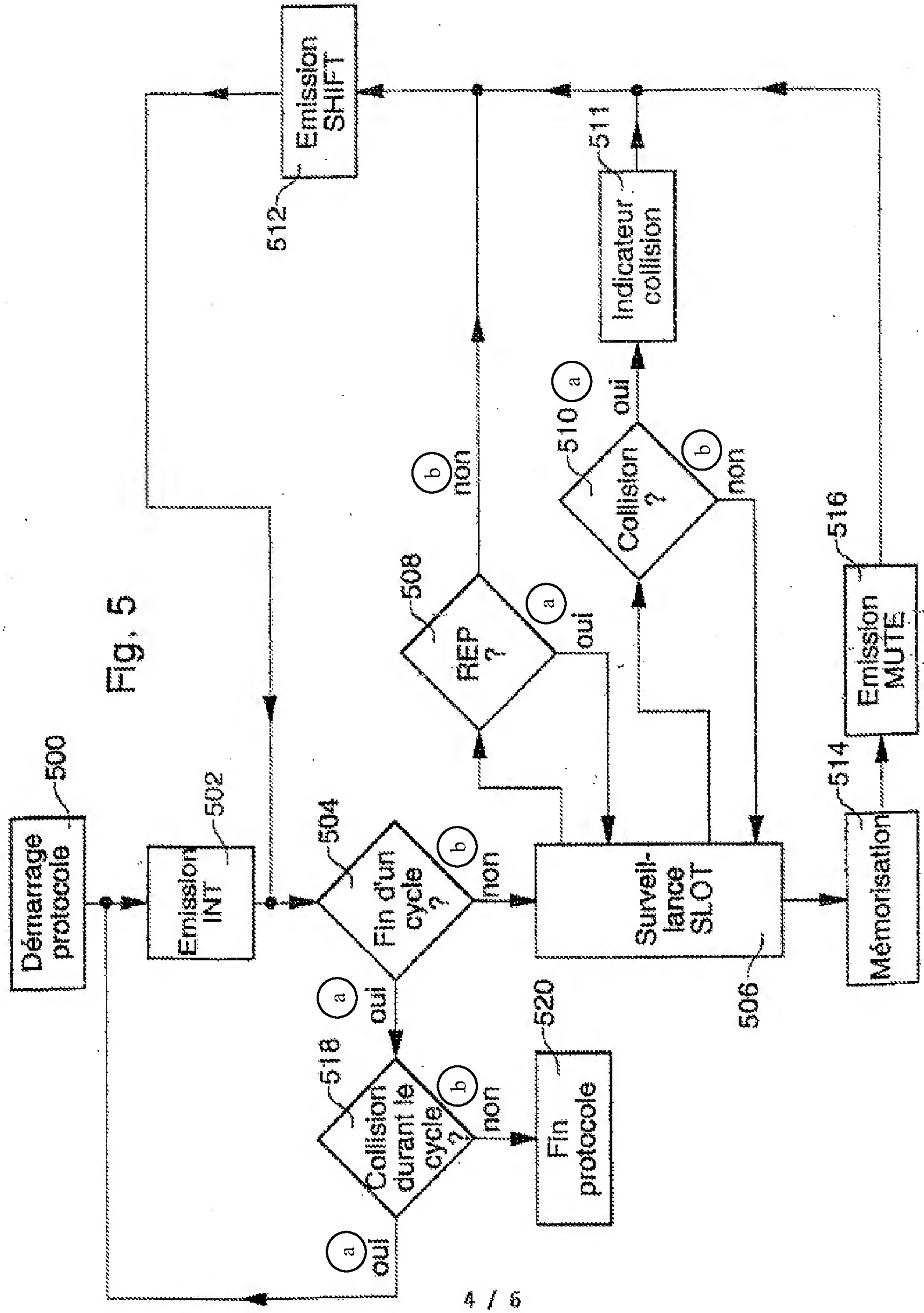


2 / 6

Fig. 4



3 / 6



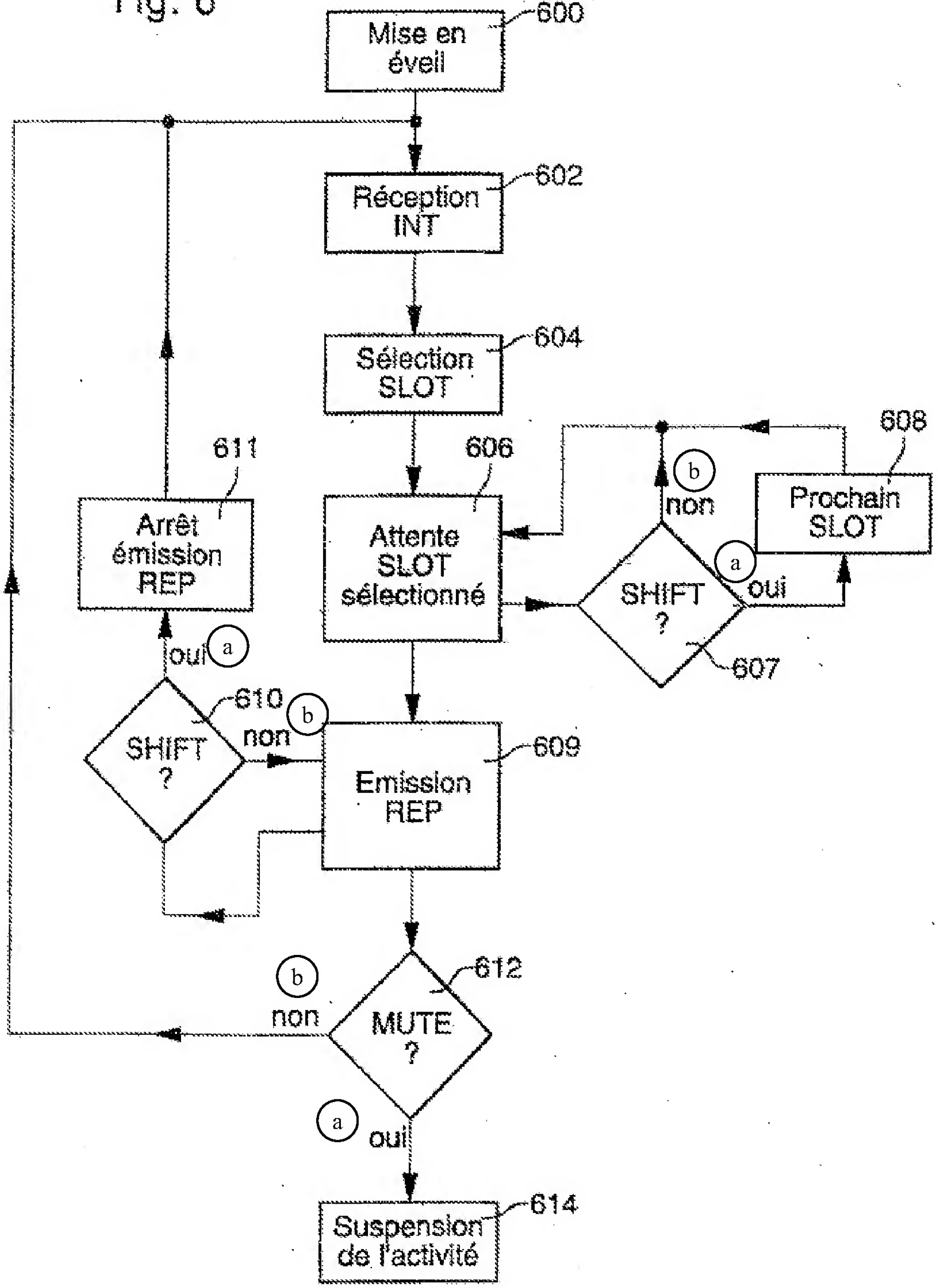
Démarrage protocole
500
Emission INT
502
Fin d'un cycle ?
504
oui
non
a
b
Surveillance SLOT
506
REP ?
508
Collision ?
510
Indicateur collision
511
Emission SHIFT
512
Mémorisation
514
Emission MUTE
516
Collision durant le cycle ?
518
Fin protocole
520

Fig. 5

4 / 6

Key:	a	yes
	b	no
	500	Startup protocol
	502	Transmission INT
	504	End of a cycle?
	506	Monitoring SLOT
	511	Collision indicator
	512	Transmission SHIFT
	514	Storage
	516	Transmission MUTE
	518	Collision during the cycle
	520	End protocol

Fig. 6



600
Mise en éveil
602
Réception INT
604
Sélection SLOT
606
Attente SLOT sélectionné
607
SHIFT ?
non
b
oui
a
608
Prochain SLOT
611
Arrêt émission REP
oui
a
610
SHIFT ?
non
b
609
Emission REP
612
MUTE ?
non
b
oui
a
614
Suspension de l'activité

5 / 6

Key:	a	Yes
	b	No
	600	Activating
	602	Reception INT
	604	Selection SLOT
	606	Wait SLOT selected
	608	Next SLOT
	609	Transmission REP
	611	Stop transmission REP
	614	Suspension of the activity

Fig. 7a

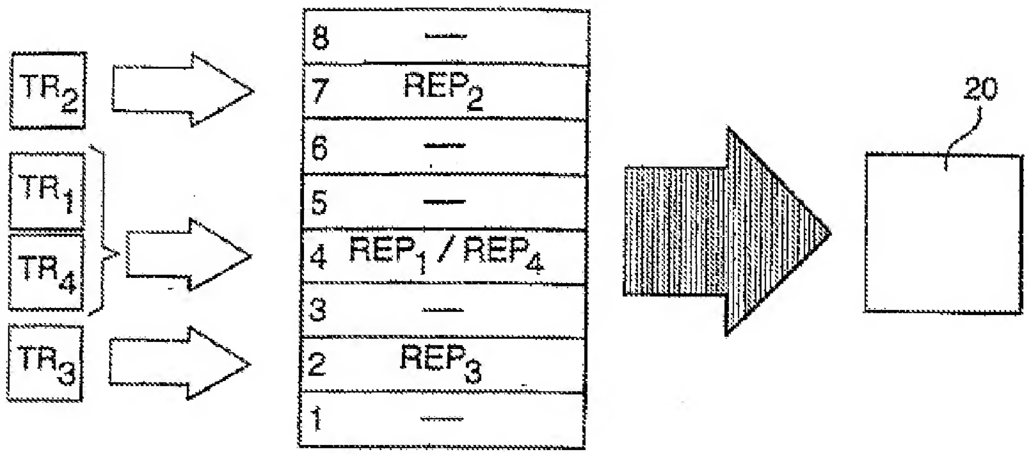
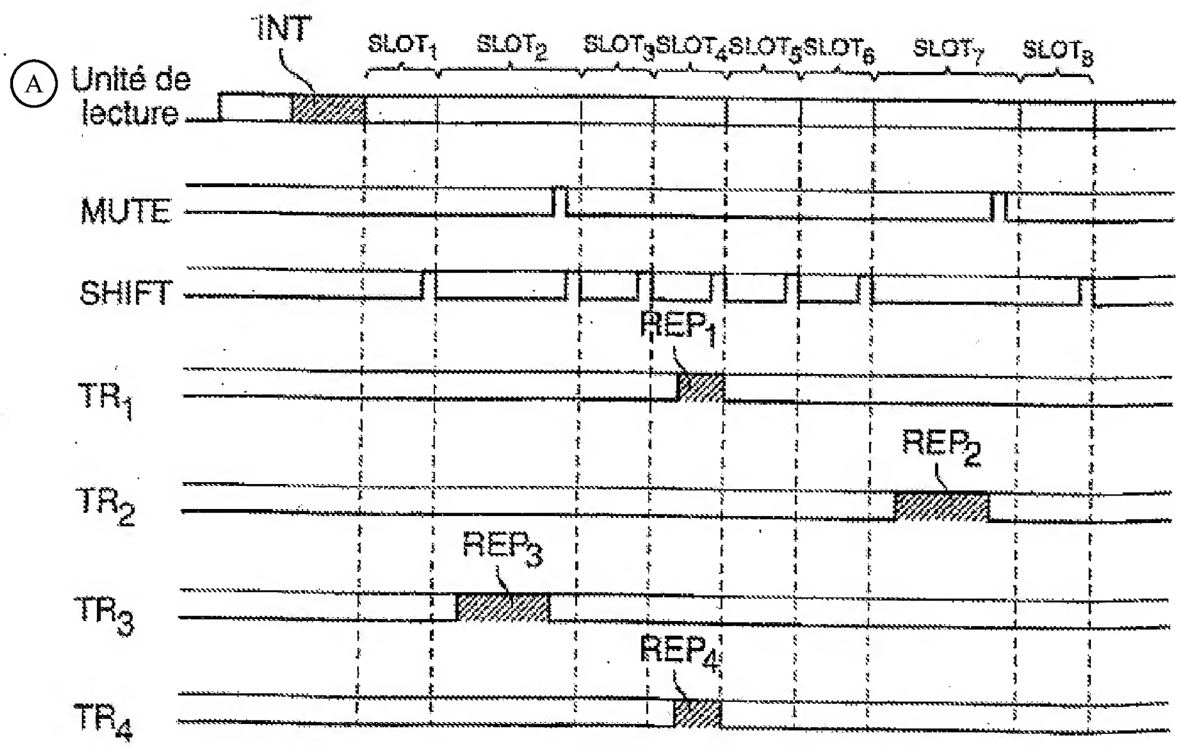


Fig. 7b



6 / 6

Key: A Reading unit